Mechanical Signalling Equipment

(British Practice)

DONALD L. CHAMPION

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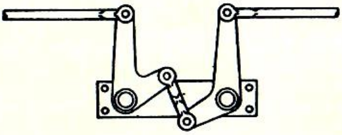
REVISED 1969



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The Institution of Railway Signal Engineers

MECHANICAL SIGNALLING EQUIPMENT

INTRODUCTION

Whilst there are many power signalling installations at busy junctions and terminal stations, and many automatic colour-light signal sections, there still remain a number of relatively large layouts and many miles of line still equipped with mechanical signalling. Thus a knowledge of mechanical signalling and its ramifications is essential to all who participate in its installation and subsequent maintenance.

The installations and apparatus herein described are selected as typical of general practice which may, however, vary in details.

PART I

SEMAPHORE SIGNALS

1 (*a*). Semaphore Signals, Posts and Fittings

Semaphore signals working in the upper quadrant are now standard, but there are lower quadrant signals still in use. Upper and lower quadrant types have much in common, such as the arm or blade, spectacles, spindle, etc., but the main difference is that the upper quadrant arm is pulled by wire to the " off " position, the weight of the arm and spectacle tending to restore the signal to normal, should the wire break. In the lower quadrant signal the spectacle casting is on the opposite side of the spindle to the arm, and is sufficiently heavy to act as a counterbalance weight to raise the arm to normal should the operating wire be broken. The lower quadrant arm is pushed " off " by a down rod, which itself acts as a counterbalance weight to restore the arm to normal. Diagram 1*a* shows the restoring torque of upper quadrant and lower quadrant arms.

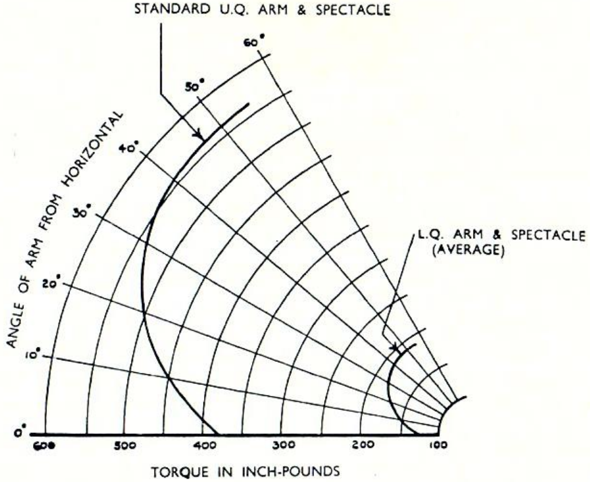
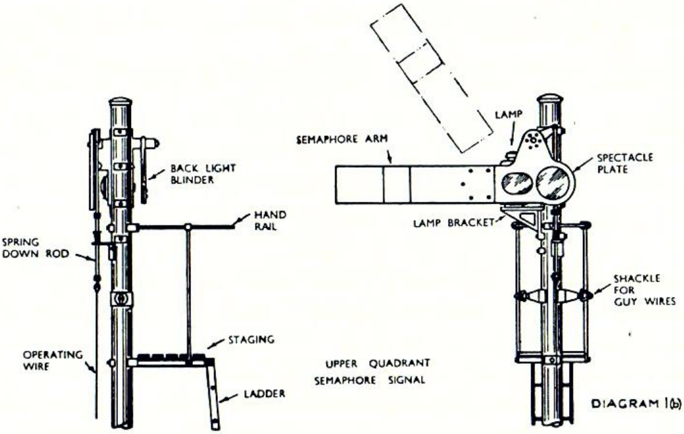


DIAGRAM 1(a)

RETURN TORQUE OF SEMAPHORE SIGNALS



UPPER QUADRANT SEMAPHORE SIGNAL

DIAGRAM 1(b)

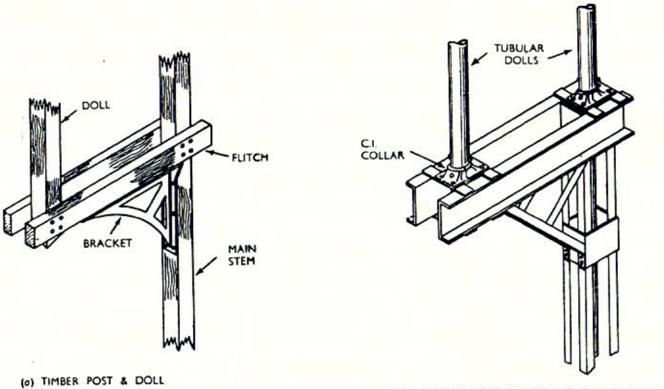
A typical upper quadrant signal is shown in diagram 1*b*. The following points should be noted. A spring loaded buffer is provided in the bearing casting, which engages with a stop on the spectacle, this considerably reduces the shock when the arm falls to normal. A short down rod is provided which includes a spring, so arranged to reduce the strain on the operating wire when the arm is pulled " off " and to act as a stop to prevent the arm moving beyond the maximum " off " position at **55°**. A back-light blinder or " blinker " is provided for those signals whose back is towards the signalman. This is arranged to obscure the white back-light should the arm be raised by more than **5°** from the horizontal. The absence of the light thus informing the signalman that either the lamp has failed or that the arm has not returned to normal since last operated.

Semaphore signals are mounted on posts which may be of timber, lattice iron, reinforced concrete or steel tubing. Lattice iron posts are heavy, relatively expensive in first cost and in subsequent painting. Reinforced concrete posts, while cheaper to construct, are exceedingly heavy, more liable to fracture in transit to site and have the disadvantage that all fixing holes must be cored at the time of manufacture, so that alterations or additions to fittings on the post are a difficult matter. Their chief merit is that they do not require periodical painting. Should the concrete be chipped or cracked down to the reinforcement, they rapidly deteriorate owing to the rusting of the reinforcing bars, which causes the concrete to flake off with increasing rapidity.

Steel tubing **5½**-in. in diameter is excellent material for posts and dolls, being relatively light and yet of stiff cross section. Its use is rapidly extending.

Where " splitting " signals are required at junctions, brackets are necessary to carry the doll posts for the extra arms. With timber posts and dolls, the normal method is to provide two timber beams, termed flitches, between which the main post and the butt-end of the dolls are bolted, the flitches being supported by cast or wrought iron brackets as shown in diagram **2*a***. In modern tubular signals, the main stem and brackets are often fabricated of welded steel angles and flats, the dolls being accommodated in cast iron collars in the brackets, diagram 2*b*.

Access to the lamps and fittings is provided by steel ladders

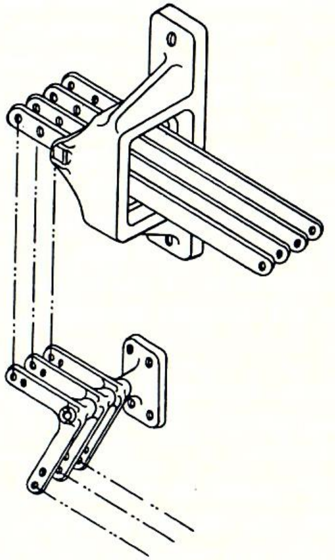


(*a*) TIMBER POST & DOLL

(*b*) ANGLE STEEL MAIN STEM & TUBULAR DOLLS

SIGNAL BRACKETS

DIAGRAM 2



QUADRUPLE BALANCE LEVERS
AND TREBLE WIRE CRANKS

DIAGRAM 3

and landing stages with open timber or metal flooring. Handrails are provided to prevent lampmen or fitters from inadvertently stepping off the landings. Stranded guy wires are installed as required to maintain the signals perpendicular during high winds or gales.

1 (*b*). Balance Levers and Wire Cranks

Signals near the signal box, which do not detect more than one pair of points, may not require balance levers and weights, the return torque of the arm and spectacle being sufficient to pull the wire back when the lever is restored to normal. In such cases a 12-in. × 12-in. wire crank is all that is required at the foot of the post. Up to three cranks are usually mounted on the same base plate, and similar cranks are used on bracket signals to take the wire round the angles at the top of the main stem and the foot of the dolls. Where signals are more than 400 yards from the box and/or detect several pairs of points, a balance lever and weight will be required to pull back the wire and its respective detector slides. Where more than one arm (except for slotted signals described below) is on the same post or bracket, the balance levers, up to four arms, can be accommodated in one casting, diagram 3.

Balance weights are added as required and are usually cast for weights of 5, 10, 20, 40, 60 and 80-lb. Set-screws are provided to hold the weights in the required position on the balance levers or where space is restricted, the balance lever is shortened and a pendant weight tail is provided on which the weights are hung. In the former case, as a precaution against weights slipping off, a bolt is fixed in the end of the balance lever.

Balance levers should be fixed at right angles to the arms. If fixed in the same place as the arms, the weights appear most unsightly when the signal is "off," particularly in the case of slotted signals, and in bad light might even be mistaken for an additional arm.

1 (*c*). Controlled or Slotted Signals

Distant signals on the same post as stop signals must be so controlled that the distant arm cannot be pulled "off" unless the stop arm above it is also "off," and in some layouts the distant arm may be controlled by one or more stop signals ahead

In short section working the starting signal for one box may also be controlled as the home signal of the next box ahead. In mechanical signalling this form of control is affected by an arrangement of balance levers, termed slots, There have been many types of slot, some of considerable ingenuity in design, but the simple " drop-off " slot, which is gravity operated, is now the standard.

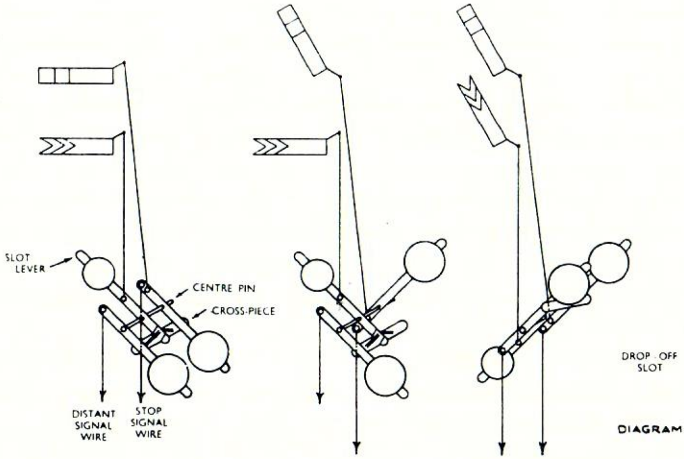
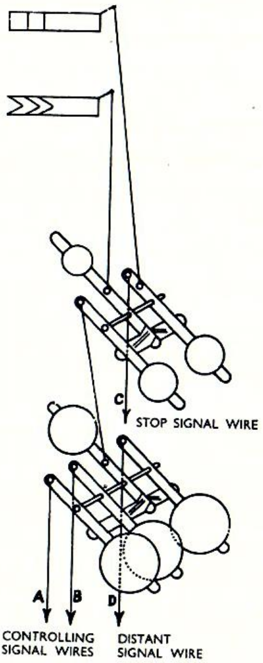


DIAGRAM 4

In the simple case of a distant arm slotted by the stop signal above, slotting is performed by three balance levers in one casting, diagram 4. The two outside balance levers are of the normal type, but the centre lever is provided with a robust cross-piece which normally lays across the underside of the outer levers. The wire operating the stop arm is connected to one of the outer levers, and the distant wire to the other. It will be apparent that the centre lever connected to the distant arm cannot drop " off " until both the operating wires have been pulled. The weights on the outer levers are each heavier than that on the centre slot lever, so that the restoration of either to normal will return the distant arm to the caution position. Since balance lever plates do not normally accommodate more than four levers, it follows that by extending the cross-piece not more than three controls can be applied to a signal arm without additional balance lever plates.

Quadruple slotting can be carried out by using two balance lever plates in series, as shown in diagram 5.



WIRES A, B, C, & D MUST ALL BE PULLED BEFORE DISTANT SIGNAL ARM IS CLEARED

QUADRUPLE SLOTTING

DIAGRAM 5.

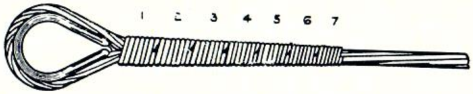
1 (*d*). Wire Connections

The movement of the signal levers in the signal box is transmitted by wires to the balance levers on the signal posts. The wire commonly used is of 7/17 s.w.g. galvanised steel, and is carried on 2-in. diameter galvanised cast iron pulley wheels, fixed on short post or " stakes " at suitable intervals. The weight of the wire gives an appreciable sag between successive stakes, so that, to take up the slack, the travel at the signal lever tail is normally more than double that required to operate the signal, which is about 8½-in.

Angular changes in the direction of a wire run are made by 12-in. × 12-in. wire cranks or by wheels. Where the travel does not exceed 16-in. the wire cranks are satisfactory, but for greater travel the crank becomes harder to operate and liable to " choke " (i.e., to become fixed on dead centre) and 10-in. or 14-in.

diameter wheels are then used, a short length of chain or wire rope being inserted in the wire run, which engages with a groove in the rim of the wheel. For economy in space, up to four pulleys can be accommodated in one frame when many wires take the same route, and double or treble wheels are used where several wires change direction of route.

Wires are attached to wire cranks, lever tails, etc., by means of shackles, the end of the wire passing over a thimble in the shackle and bent back on itself, the individual strands being neatly wound round as shown in diagram 6.



SIGNAL WIRE AND THIMBLE JOINT

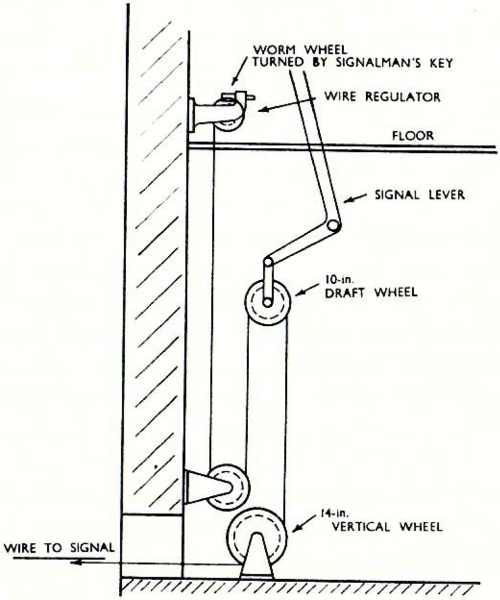
DIAGRAM 6

Signal wire is liable to stretch somewhat during the first few weeks after installation and, to keep the apparatus in correct working order, adjusting screws or turnbuckles are inserted in the wire run at the lever tail and at each detector.

In common with most materials, signal wire expands or contracts with changes of temperature, the coefficient of linear expansion of steel being 67×10^{-7} per degree Fahrenheit, so that for an annual change in temperature of 100°F., the change in length of signal wire would be 2·41-in. per 100 yards. In the case of outer distant signals, these may be located as much as 2,000-yds. from the signal box; and a drop in temperature of 50°F. on a cold night after a hot day would shorten the wire by as much as *two feet*, sufficient to pull the arm " off." To overcome this difficulty, the end of the wire in the signal box is carried on to the drum of a wire regulator, which enables the signalman to pay out or draw in the wire as required.

Owing to the slackness of the wire and changes in length with temperature, signals more than 400 yards from the signal box require more stroke at the lever tail than can normally be obtained.

This is overcome by the provision of gainstroke or draft wheels, hung from the lever tail, which double the stroke of the wire. The normal arrangement of the wire regulator and draft wheel is shown in diagram 7.



WIRE REGULATOR AND DRAFT WHEEL

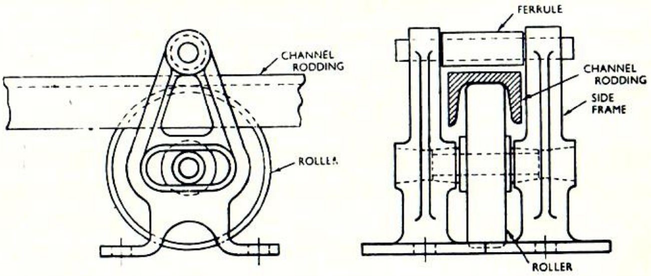
DIAGRAM 7

PART II

POINTS AND LOCKBARS

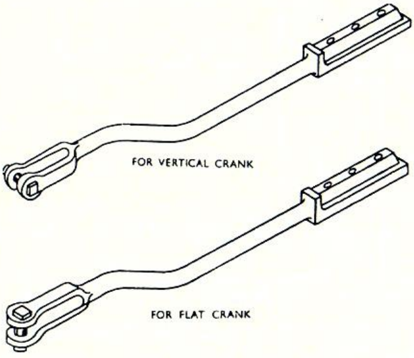
2 (*a*). (i) **Rod Connections**

Facing and trailing points, lockbars, clearance bars, etc., are usually operated by rodding of rolled steel channel, 1⅝-in. × 1¼-in. × ¼-in. section, this being rolled into convenient lengths which are joined by fishplates fixed by bolts in the channel.



CHANNEL RODDING ROLLER

DIAGRAM 8


FOR VERTICAL CRANK

FOR FLAT CRANK

PIN JOINTS FOR CHANNEL ROD

DIAGRAM 9

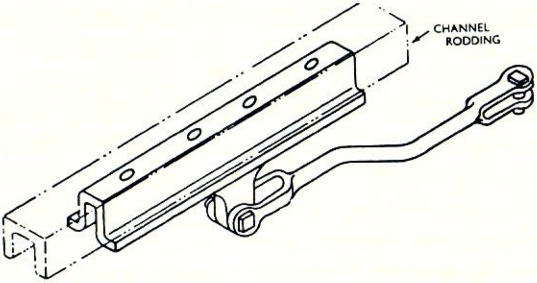


DIAGRAM 10

LUG CONNECTION

The rodding is carried on rollers in frames, fixed at suitable intervals, and a small roller or ferrule is provided above the rods to prevent any undue distortion in a vertical plane, diagram 8. Rodding being relatively inflexible, changes in direction are obtained by the use of cranks, the rods being connected to the crank arms by means of pin joints, forged of 1¼-in. diameter solid steel rod, with ends stamped in channel section to fit the rodding, diagram 9.

When more than one pair of point tongues are operated by the same rod, such as a crossover road, the end nearest the signal box is operated by the provision of a lug fixed in the channel, from which a short rod with a pin joint each end is taken to the crank, to which the drive rod is connected, diagram 10. The last crank in the run, to which the drive rod is connected, is usually made with an adjusting sleeve on one arm, so that the correct stroke may be given to the point tongues, irrespective of the travel of the rodding. Adjusting screws and screw-joints are used when required, to obtain the correct length of rod connections. Where there is not sufficient room to include an adjusting screw in the drive rod from the permanent way stretcher bar to the adjusting crank, the drive rod may be coupled to a lug on the stretcher bar bracket on the remote side of the track, diagram 11.

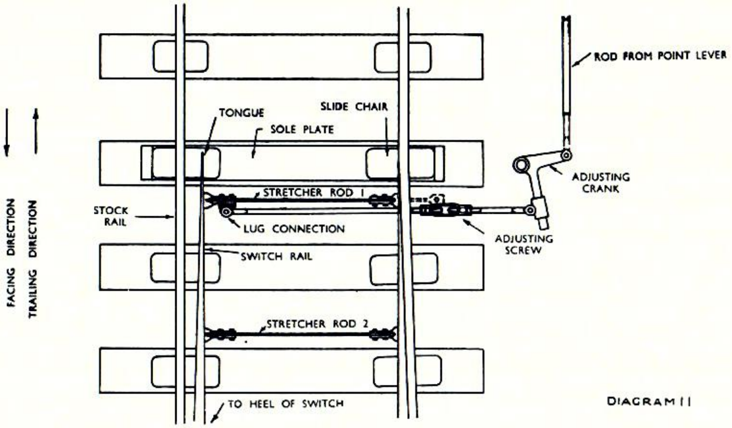
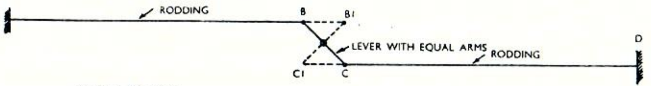


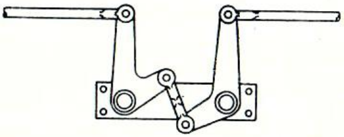
DIAGRAM 11

2 (*a*). (ii) **Compensation—Single Ended Points**

The greatest natural changes in temperature are found at or near ground level, and this renders point rodding very susceptible to climatic variations. The annual temperature range of point rodding in this country may be as high as 140°F., and the daily range as much as 80°F. Owing to the force required to move the rodding and the point tongues, the practical limit of manually operated points is 350 yards from the signal box and is so established by Ministry of Transport Regulations. Nevertheless, the effects of temperature on such a length of rodding are considerable. The maximum diurnal change in length of 350-yds. nominal of rodding is 6¾-in., and the greatest annual change may be twice as much, i.e., 13½-in. Since the normal travel of point tongues is but 4¼-in., it follows that changes in temperature could not only reverse the points without the lever being moved by the signalmen, but such overstroke could be applied that the rods would be buckled by the strain.



(a) THEORY OF COMPENSATION

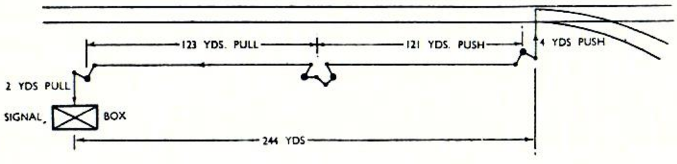


(b) COMPENSATOR

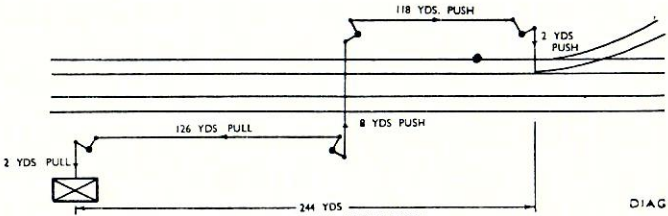
DIAGRAM 12

It is, therefore, necessary for all rods exceeding 10-yds. in length to be compensated for changes in temperature, and this is done by inserting a system of levers or cranks, termed compensators, mid-way in the run of rodding, so arranged to reverse the motion of the rods. It will be seen in diagram 12*a* that if " A " and " D " be fixed ends of rods, and a straight lever or scale-beam " BC " be fixed so that rod " AB " is equal in length to the rod " DC," then if rod " AB " expands to " AB," rod " DC " will also expand to " DC." So that any change in the length of rodding between " A " and " D " due to temperature change will automatically be taken up by the movement of the lever " BC," the relative position of the ends of the rods at " A " and " D " remaining constant. In actual practice, in order to preserve the alignment of the rodding, the straight lever is usually replaced by an acute and an obtuse crank mounted on the same base and connected by a link, as shown in diagram 12*b*.

For correct compensation it follows that, in a given run of rodding, the total amount of rod in tension or "pull" must equal the total amount in compression or "push."



(*a*) SINGLE ENDED POINTS

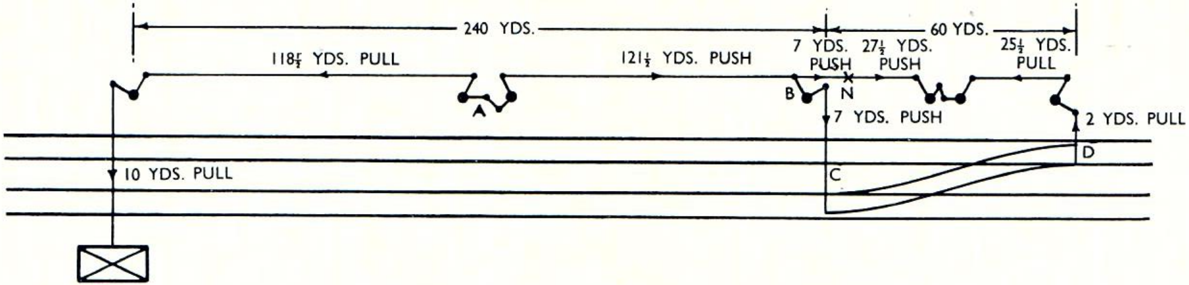


(*b*) CRANKS USED AS COMPENSATOR

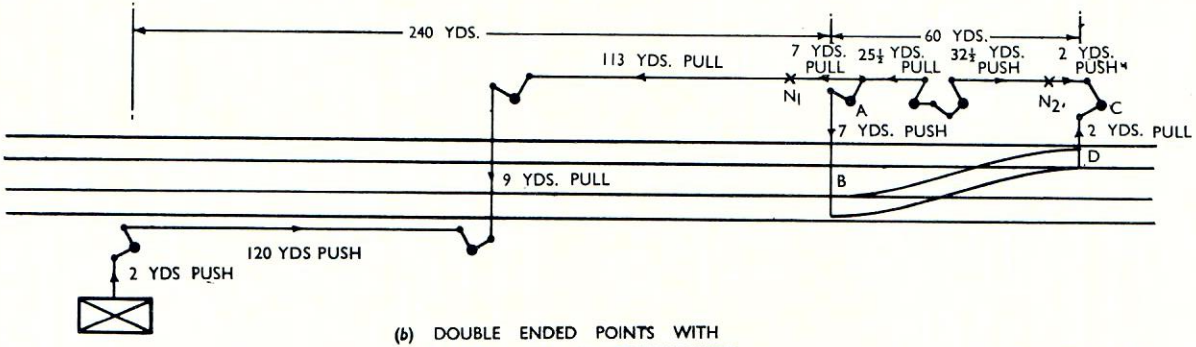
DIAGRAM 13

Diagram 13*a* shows a simple case of a pair of points 244-yds. from the signal box. Assuming all cranks equal, it will be noted that the total length of rodding is 250-yds., made up of 2-yds. pull from the lever to the first crank, 123-yds. of pull to the compensator, 121-yds. of push to the last crank and 4-yds. of push in the drive rods to the points. In cases where it may be necessary to cross under the track to operate the points, the compensator may be dispensed with, the compensation being carried out with the cranks each end of the cross rod. In diagram 13*b*, again assuming all cranks equal and the points at 244-yds. from the signal box, it will be noted that the total length of rodding is 256-yds.

The cross rod is known to be 8-yds. long and the lead-off and drive rods each 2-yds. in length. The position of the cross rod is found to be 126-yds. from the signal box and 118-yds. from the points (126+118=244-yds.), made up thus:—2+126=128-yds. in pull and 8+2+118=128-yds. in push.



(*a*) DOUBLE ENDED POINTS



(*b*) DOUBLE ENDED POINTS WITH CRANKS USED AS COMPENSATOR

DIAGRAM 14

2 (*a*). (iii) **Compensation—Double Ended Points**

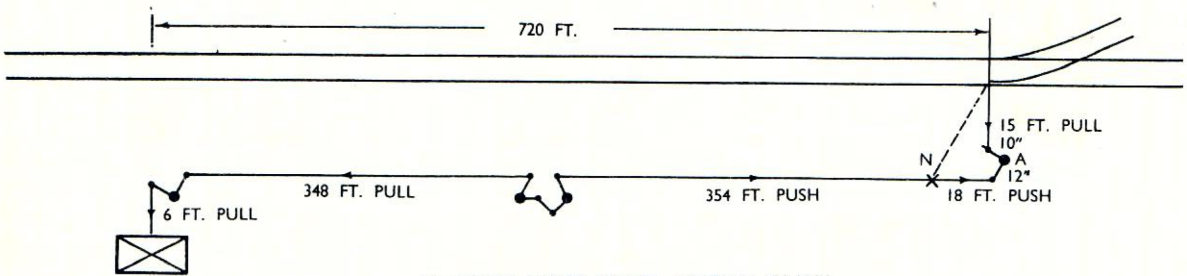
In cases where more than one pair of points are worked by the same run of rodding, such as a crossover road, separate compensation has to be applied to each connection. In a simple case with all cranks equal, diagram 14*a*, the section of rodding between the signal box and the first pair of point tongues is compensated as shown. It will be noted that the compensator at " A " will also compensate a portion of the rod run beyond the crank " B," equivalent to the length of the cross rod " C," up to the neutral point " N." The remainder of the run to the point " D " is separately compensated by the compensator at " E." Check on the above : $10+118\frac{1}{2}+25\frac{1}{2}+2=156$-yds. in pull, $121\frac{1}{2}+7+27\frac{1}{2}=156$-yds. in push.

Diagram 14*b* shows the arrangement of the compensator when a crossover road is operated by rodding which crosses under the track, in the manner described above for single ended points, but with the motion reversed. It will be noted that there are two neutral points. " N1 " which is 7 yards from the crank, to compensate for the 7 yards push in rod " B," and " N2 " 2 yards from crank " C," to compensate for the 2 yards pull in rod " D." Check as before :— $9+113+7+25\frac{1}{2}+2=156\frac{1}{2}$-yards in pull, $2+120+32\frac{1}{2}+2=156\frac{1}{2}$-yards in push.

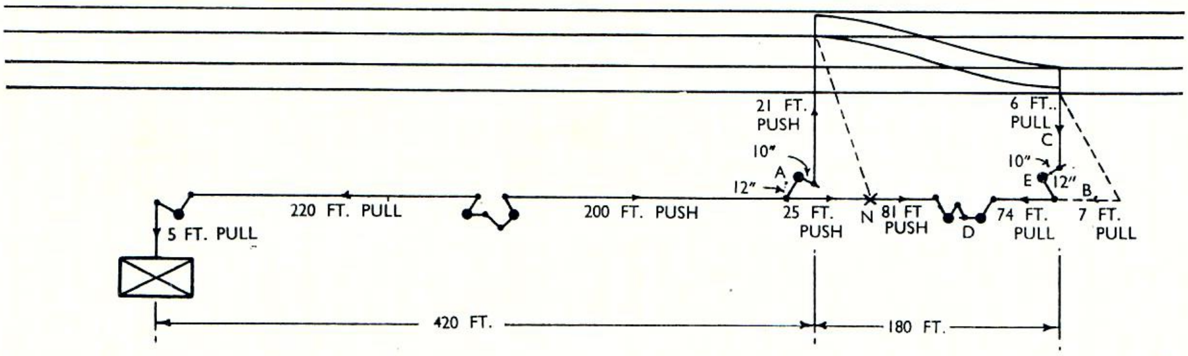
2 (*a*). (iv) **Compensation with Unequal Cranks**

In order to obtain ample strokes at the points, the travel of the rodding is usually greater than that actually required to move the former from normal to reverse. It is then necessary, by means of an adjusting sleeve, proportionally to shorten the crank arm to which the drive rod is connected.

Assuming the travel of the rod at the last crank in the run to be 5-in., and the travel of the points tongue is the normal $4\frac{1}{4}$-in. ; then with 12-in. crank arms, the adjusting arm of the crank must be reduced to $\frac{4{\cdot}25\times12}{5}=10{\cdot}2$-in. Under these circumstances the rule that the amount of rod in pull must equal that in push no longer applies, and the lengths must be adjusted in accordance with the ratio of the lengths of the crank arms. To avoid decimal fractions of yards, it is convenient to work to the nearest foot. In diagram 15*a*, a single pair of points working to the above conditions is shown, and it will be seen that the neutral point



(a) SINGLE ENDED POINTS, UNEQUAL CRANK



(b) DOUBLE ENDED POINTS, UNEQUAL CRANKS

DIAGRAM 15

" N " is now 3-ft. nearer the signal box than it would have been if the crank "A" had equal arms, the distance "B"

$$= \frac{15 \times 12}{10.2} = \text{18-ft. approximately.}$$

Diagram 15*b* shows these conditions as applied to a crossover road, and it will be noted that the neutral point is carried 25-ft. beyond crank " A," and the equivalent length " B " of rod " C " is allowed for in fixing the compensator " D," which should be 81-ft. from the neutral point and 74-ft. from the crank " E."

2 (*a*). (v) **Setting of Compensators on Installation**

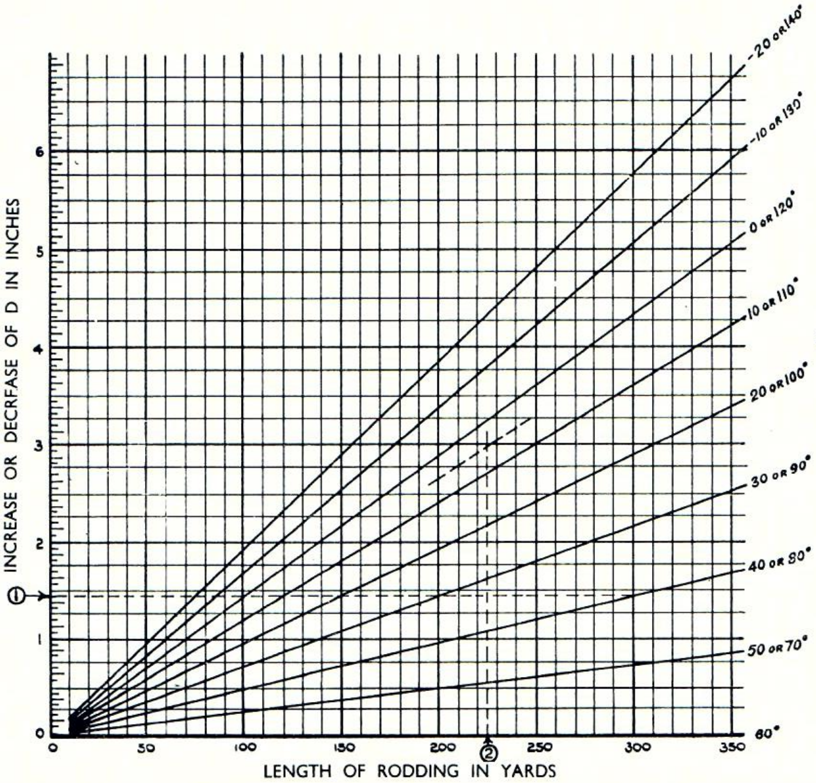
It is obvious that point rodding connections cannot always be installed at some standard temperature, and when fixing compensators, allowance must be made for the difference in temperature of the rodding from the mean of the range of temperature to which it may be exposed.

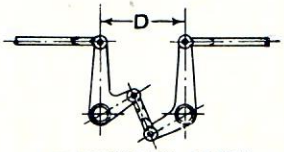
In extreme cases, on a calm, clear, frosty night in winter, the loss of heat by radiation may chill down rodding to a temperture as low as 20°F. below zero. On the other hand, on a calm, hot, sunny day in summer, the rods may reach a temperature as high as 140°F., an extreme range of 180°F., with a mean value of 60°F. Rodding should be installed with the lever in the signal box, and all cranks at mid-stroke.

At the standard temperature of 60°F., the two longer arms of the compensator should be at mid-stroke and thus be parallel with each other. If, at the time of installation, the temperature of the rods is *lower* than 60°F., the arms of the compensator should be set *outwards* by an amount depending on the deviation of the temperature below 60°F., and the length of rod to be compensated. Conversely, if at a temperature *above* 60°F., the compensator arms must be set *inwards* by a corresponding amount. The amount of adjustment between the arms for any length of rod up to 350-yds., within the temperature range specified above, can be readily obtained from the graph, diagram 16.

2 (*b*). **Facing Point Locks and Lockbars**

In order to prevent the movement of facing points between the wheels of a train passing over them, facing point locks and lockbars are provided. A facing point lock stretcher bar is bolted between the point tongues and passes through a slot in the





COMPENSATOR AT 60°F.

FOR TEMPERATURES BELOW 60°F. OPEN CRANKS (OR INCREASE D) BY AMOUNT SHOWN ON GRAPH.

FOR TEMPERATURES ABOVE 60°F., CLOSE CRANKS (OR DECREASE D) CORRESPONDINGLY.

EXAMPLES:

(1) LENGTH OF RODDING TO BE COMPENSATED=300 YARDS. TEMPERATURE OF RODDING=40°F. THEN D MUST BE INCREASED BY $1\frac{7}{16}$"

(2) LENGTH OF RODDING TO BE COMPENSATED=225 YARDS. TEMPERATURE OF RODDING=115°F. THEN D MUST BE DECREASED BY 3"

COMPENSATION CHART

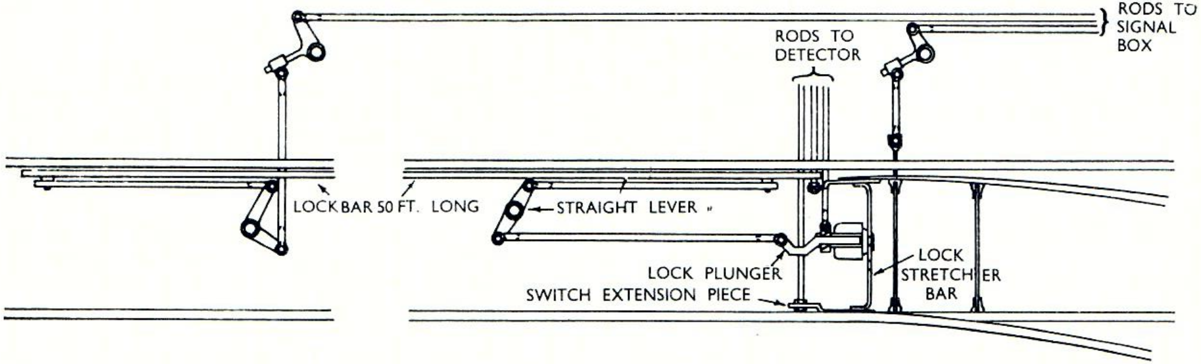
DIAGRAM 16

facing point lock casting. Notches are cut in this bar through which a plunger, operated by the f.p. lock lever in the signal box, is passed when the points are locked. One notch is provided for the normal and one for the reverse position of the points. The plunger is driven by rodding through a lifting bar 50-ft. in length, diagram 17, the lifting bar being provided to prevent the plunger being moved when a vehicle is passing over it. The lockbar is carried on clips bolted to the stock rail ahead of the point tongues. The bar is usually of tee section rolled steel, and is attached to the clips by levers or " half-cranks," so arranged that at half-stroke the bar is lifted above rail level. Should a pair of wheels be on the rails, it will be seen that the bar would be prevented from lifting by engaging with the flange on the tyre, thus preventing the plunger from being withdrawn from the stretcher bar. The clips are so spaced that the bar cannot bend sufficiently between wheels for the lock to be forced.

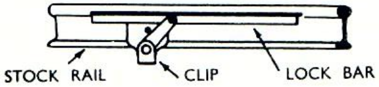
Should there be another pair of points or a crossing immediately ahead of the facing points, so that there is insufficient room for the lockbar, the latter, in the past has been replaced by two bars, one along each point tongue. This method is both expensive to install and difficult to maintain, and present day practice is to provide a short length of track circuit through the points, controlling an electric lock on the f.p. lock lever, the latter operating the plunger directly instead of through the lockbars.

A cam operated detector slide is provided in the f.p. lock which is connected to a blade in the signal detector, so that the signals leading over the points cannot be cleared unless the points are correctly bolted.

It should be noted that, owing to its length, the lockbar is usually made in two or more sections connected by fishplates and bolts. To ensure that the whole of the bar is moved each time the plunger is operated, the connections from the signal box are made at the end of the bar remote from the points, and the plunger is connected to the end nearest the points. Since the weight of a 50-ft. lockbar is about 1½-cwt. and, with the additional weight of the rail clip arms, has to be lifted every time the plunger is operated, spring loaded " assisters " are often provided on the driving crank arm, diagram 18. These assisters not only ease the work of the signalman, but also reduce the shock when the



LAYOUT OF F.P. LOCK AND LOCK BAR
(SLEEPERS NOT SHOWN)



DETAIL OF RAIL CLIP FOR LOCK BAR

DIAGRAM 17

bar is lowered on to its rests, which take the weight when the bar is fully normal or reverse.

Where a rail joint is placed in the stock rail alongside a lockbar, the expansion joint is filled by a suitable packing piece. If this is not done, the lockbar would become distorted in hot weather due to the progressive increase of movement of the rail clips towards the joint. The insertion of the packing piece ensures equal amount and direction of expansion of the rail and bar between the clips.

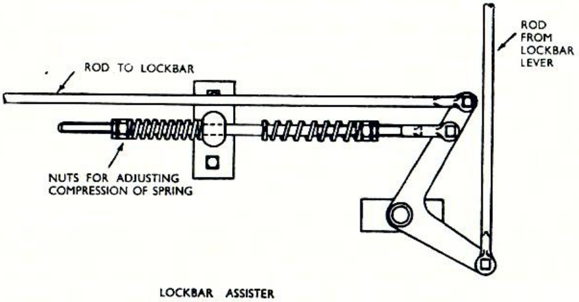


DIAGRAM 18

PART III

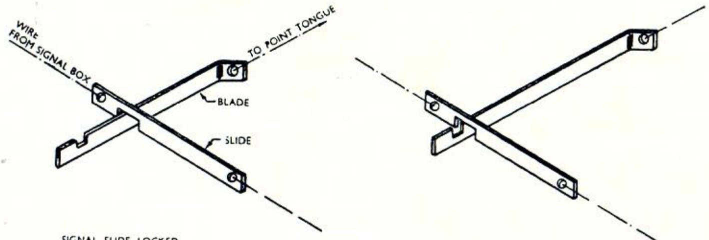
DETECTORS

3 (*a*). Principles of Detection

In mechanical signalling, in addition to the interlocking between point and signal levers, apparatus known as detectors are provided to ensure that the point tongues are correctly normal or reverse before the respective signals can be cleared. In the case of facing points, not only is the position of both point tongues detected, but the lock plunger must also be proved " in " before the signals can be pulled " off."

The common arrangement of a simple detector is shown in diagram 19. The signal slide in the wire run is mounted in a casting and is provided with a notch through which the blades from the point tongues or facing point lock plunger are passed.

Notches are cut in the blades which coincide with those in the signal slide when the points are correctly normal (or reverse), thus releasing the slide for the respective signals.



SIGNAL SLIDE LOCKED

SIGNAL SLIDE FREE

PRINCIPLE OF DETECTION

DIAGRAM 19

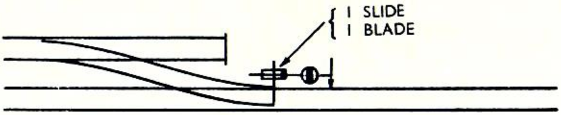
Diagram 20*a* shows the simple case of a disc signal leading through a pair of trailing points in the reverse position only. In this case only one blade is required, which is connected to the normally closed point tongue.

Where a disc signal leads through a pair of trailing points both normal and reverse, such an " A " in diagram 20*b*, up to the disc " B," the detector for signal " A " will have two blades, one from each point tongue.

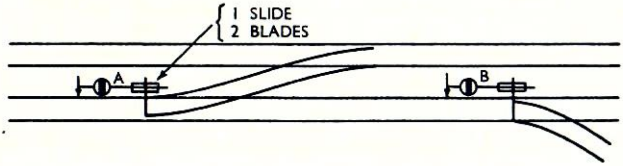
In diagram 20*c* the detector will have two slides, one for signal " A," which is free when the points are normal, and one for signal " B," which is free only when the points are reversed. Three blades are provided, one from each point tongue and one from the f.p.l. plunger.

3 (*b*). Installation and Adjustment of Detectors

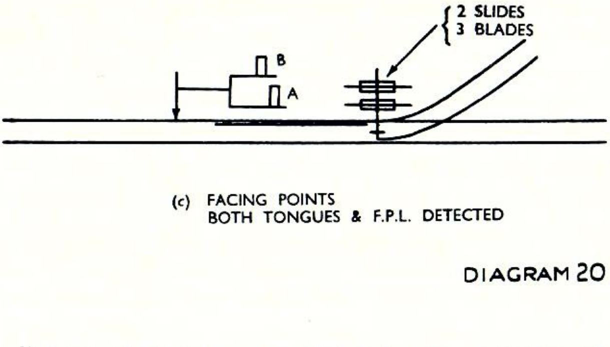
The length of the signal slide in detectors must be sufficient to permit the full travel of the signal wire, or the shackle at the signal end of it will foul the casting through which the slide is passed, thus preventing the full clearance of the signal. The actual travel will, of course, vary with the position of the detector in the wire run.



(a) TRAILING POINTS
ONE TONGUE ONLY DETECTED



(b) TRAILING POINTS
BOTH TONGUES DETECTED

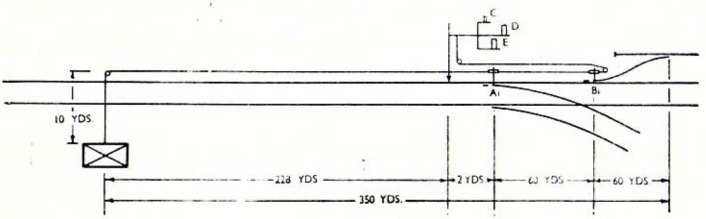


(c) FACING POINTS
BOTH TONGUES & F.P.L. DETECTED

DIAGRAM 20

In diagram 21 it will be noted that the signal " C " is 228-yds. from the signal box, but since this signal detects the points to the loop ahead of it, the total length of the wire run is 362-yds. Assuming a stroke of 9-in. at the lever tail, a gainstroke wheel will be required, which will increase the travel to 18-in. Assume the stroke at the balance lever of signal " C " to be 8½-in., then the total loss of stroke in the wire will be 18-8½=9½-in. in 362-yds. This is almost exactly 2⅝-in. per 100-yds.

Detector " A " is 240-yds. from the lever in the signal box and the travel of its slide would be $11\frac{13}{16}$-in., whereas at " B " the travel would be reduced to 10⅛-in.



TOTAL LENGTH OF WIRE RUN - 362 YDS.
TRAVEL OF WIRE AT LEVER TAIL - 18 INS.
" " " " SIGNAL - $8\frac{1}{4}$ INS.
TOTAL LOSS OF TRAVEL IN RUN - $9\frac{3}{4}$ INS. - $2\frac{3}{4}$ INS. PER 100 YARDS
TRAVEL AT DETECTOR A - $11\frac{11}{16}$ INS.

DIAGRAM 21

The normal allowance in the notch of the signal slide is $\frac{3}{4}$-in., but owing to the greater travel of the slide in detector " A," the notch clearance therein may be increased by $\frac{5}{16}$-in. This will reduce the chances of failure of the detector due to slack in the wire run when the signal is restored to normal.

When more than one signal detects the same pair of points, it is imperative that the normal notches in the point blades shall not conflict with the reverse notches when the points are thrown, otherwise the normal notch for one signal might free another which should be locked when the points are reversed. Diagram 22 shows the arrangement of the notches in the blades of detector " A " in diagram 21, and it will be noted that the signal slides are so spaced that the distance between them is greater than the normal throw of the points, so that when the points are reversed, the normal notch for one slide does not reach the adjacent signal slides, or vice versa.

Since the function of detectors is to determine that points are correctly set and locked before signals leading through them can be cleared, it follows that once correctly installed, no further adjustments may be made. Should the stock rails become sufficiently worn to throw the notches of a detector out of adjustment, the permanent way department concerned must insert packing pieces, termed " shims," between the stock rail and the jaw of the slide chair to restore the points to correct gauge.

In order that detectors should not be displaced relative to the stock rails after installation, they should be fixed on the same timbers as the slide chairs. If this is impossible, the detector should be placed on a floating base and tied to the stock rail by means of rodding. This allows for slight movement from or to the

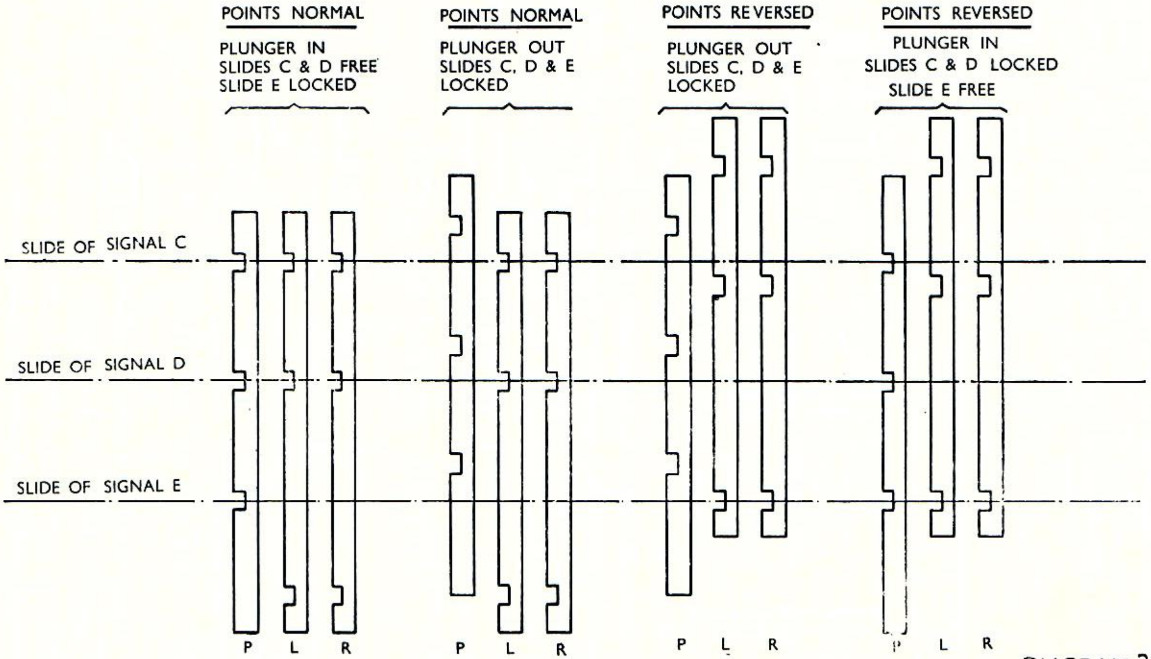


DIAGRAM 22.

NOTE: BLADES P, L, R, CONNECTED TO PLUNGER, LEFT AND RIGHT-HAND POINT TONGUES RESPECTIVELY stock rail with the expansion or contraction of the detector rods, and ensures that there shall be no relative movement of the blades which would throw the detector out of adjustment, diagram 23.

PRINCIPLE OF FLOATING DETECTOR

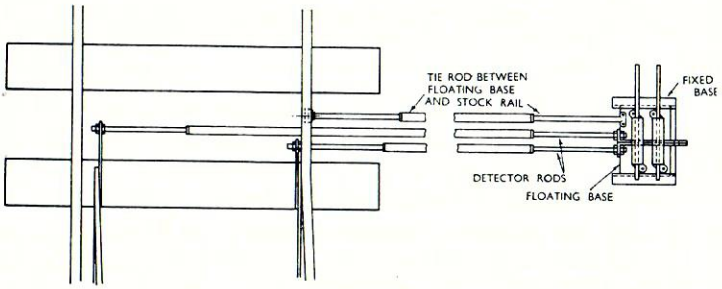
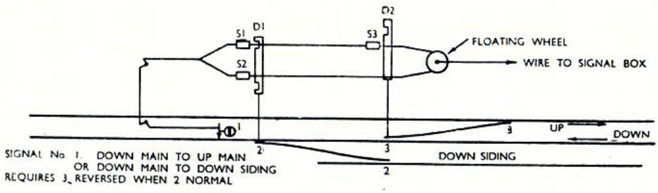


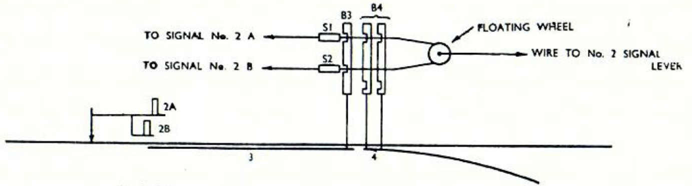
DIAGRAM 23.

3 (*c*). Special Cases of Detection

Where a disc signal applies to more than one route, special detection has to be applied to ensure that traffic is not signalled over a wrong route. In diagram 24*a*, the disc signal No. 1 applies either to the down siding or through the crossover to the up line, and it must not be cleared for a movement in the wrong direction on the down line.


D2
D1
S1
S3
S2
FLOATING WHEEL
WIRE TO SIGNAL BOX
1
3
UP
DOWN
2
3
DOWN SIDING
2
SIGNAL No. 1. DOWN MAIN TO UP MAIN
OR DOWN MAIN TO DOWN SIDING
REQUIRES 3, REVERSED WHEN 2 NORMAL

(*a*) SIGNAL APPLYING TO MORE THAN ONE ROUTE



(*b*) SELECTED SIGNALS

DIAGRAM 24

A double wire is provided with two slides " S1 " and " S2 " in the detector " D1 " on points No. 2, and one slide " S3 " in the detector " D2 " on points No. 3. This wire is passed round a floating wheel, the frame of which slides in bearings and is connected to the wire from the signal box.

It will be seen that with points No. 2 normal, the signal cannot be cleared unless points No. 3 are reversed, the detectors thus simulating the special locking between the respective levers in the signal box.

Detectors can also be arranged as selectors whereby two signals may be coupled to the same lever in the signal box. In diagram 24*b* it will be seen that wire is led from signal No. 2*a* to detector slide " S1," thence round a floating wheel to detector slide "S2 " and back to signal No. 2*b*. The operating wire from the signal box is connected to the frame of the floating wheel. When points No. 4 are normal and the lock plunger No. 3 is in, slide " S1 " is free to be pulled but " S2 " is locked. With points No. 4 reversed and plunger No. 3 in, slide " S2 " is free and " S1 " locked. The notches in the blades " B4 " from the points thus select which signal shall be cleared when signal lever No. 2 is pulled.

PART IV

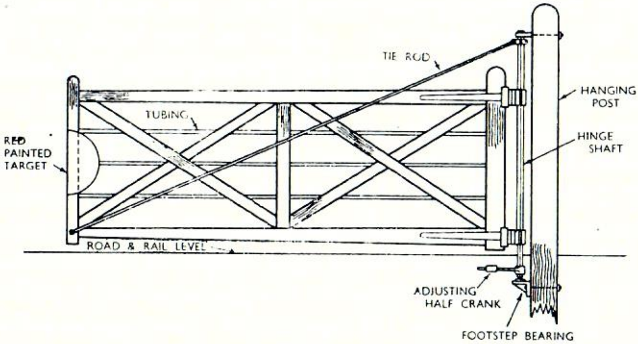
LEVEL CROSSING GATES

4 (*a*). Gates and Gate Wheels

There are a great number of level crossings on British Railways but, in the past, there has been little standardisation of gates and connections. Nevertheless there is considerable similarity in general types and methods of operation. When gates are operated from the signal box, it is usual to provide four gates which are moved simultaneously by means of rodding driven by some form of wheel, which is manually operated by the signalman.

Gates are commonly constructed of timber frames, with tubular bars or covered with expanded metal, but wrought iron or steel gates are sometimes provided. The gates are hung on shafts supported in bearings fixed to heavy posts of timber, cast iron or concrete, and are provided with red painted targets about 3-ft. in diameter in the centre and with red lamps for use at night.

For a roadway 30-ft. wide, two pairs of gates, each 15-ft. long, would be provided, and it will be apparent that the considerable weight of the gates would tend to make them droop slightly "out of square," and to obviate this, a tie rod with adjusting screw is provided on each gate to take the weight. Wider roads may require gates up to 30-ft. in length, and it is then necessary to extend the hanging post and fit an extra tie rod. In order to prevent binding, in actual practice the gates are made about $\frac{3}{4}$-in. shorter than the nominal length. A typical gate is shown in diagram 25.

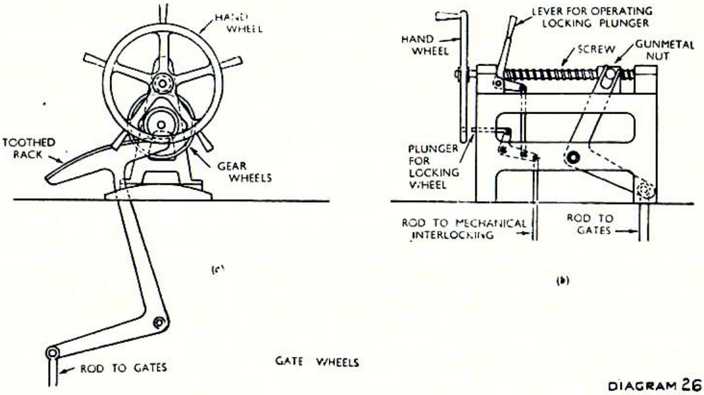


LEVEL CROSSING GATE

DIAGRAM 25

The footstep and hinge bearings are usually provided with gun-metal bushes, held by set-screws which permit slight lateral adjustment. This is required to allow the gates to rise or fall with any camber in the roadway such as would occur if the crossing were on a hillside.

The motion of the rodding from the gate wheel is transmitted to the gate shaft by means of cranks or by rack and pinion, the latter being preferable for gates on skew crossings which have to travel through more than a right angle. The more common types of gate wheel are (1) the capstan type, diagram 26*a*, provided with toothed gear wheels engaging with a rack-quadrant which is attached to the vertical crank to which the rodding is connected; and (2) the horizontal screw type, diagram 26*b*, which is attached to a screw shaft on which is threaded a gun-metal nut with a two-start or three-start thread. The nut is provided with trunnions which engage with a fork in the end of a vertical crank to which the drive rodding is connected. The wheels are interlocked with the gate stop lever in such a manner that the stops cannot be operated unless the gates are in the correct position. The gate wheels are fixed at the end of the locking frame nearest to the crossing, so that the signalman can observe the road traffic when operating the gates.

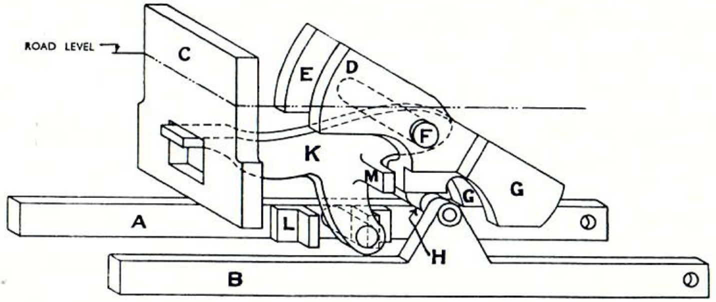

HAND WHEEL
TOOTHED RACK
GEAR WHEELS
ROD TO GATES
(a)
LEVER FOR OPERATING LOCKING PLUNGER
HAND WHEEL
SCREW
GUNMETAL NUT
PLUNGER FOR LOCKING WHEEL
ROD TO MECHANICAL INTERLOCKING
ROD TO GATES
(b)

GATE WHEELS

DIAGRAM 26

4 (*b*). Gate Stops

In order to limit the travel of the gates, gate stops are provided in the roadway and in the six-foot, known as road and rail stops respectively. The stops are controlled by rodding from the gate stop lever in the signal box, which is interlocked with the signals governing the movement of trains over the crossing. The gates are normally closed across the railway and have to be opened for the passage of trains. The road stops would be a source of danger to road traffic, and are therefore lowered to road level when the gates are across the railway, but are automatically raised when the gates are approaching them. A typical set of road stops is shown in diagram 27. The stops are shown raised and locked in position to hold the gates. Slide " A " is operated automatically by escapement gear from the rod driving the gates, and slide " B " is worked by the gate stop lever. The back stop " C " and the front stops " D " and " E " are mounted free to rotate on the spindle " F." The front stops are provided with balance weights " G."



ROAD STOPS

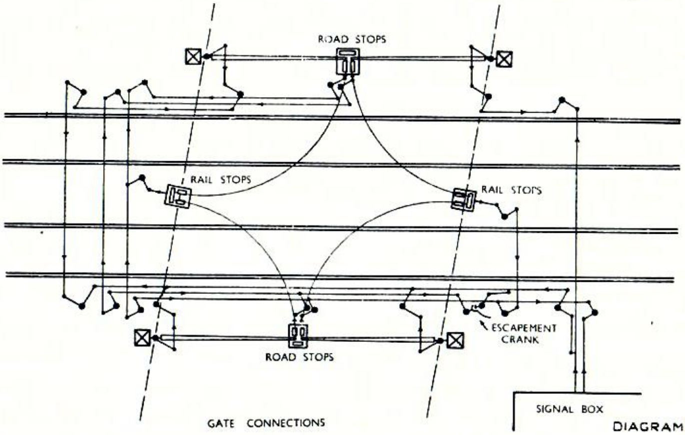
DIAGRAM 27

The *modus operandi* is as follows :—To open the gates for road traffic, the gate stop lever is moved to the reverse check-lock position, which moves slide "B" to the right and, by means of the pin " H " engaging with the underside of the weights " G," the front stops are forced down, thus releasing the gates. This movement of the gate stop lever also locks the levers of all conflicting signals in the locking frame and releases the gate wheel. The gates are then opened by the gate wheel, and slide " A " moves along to the right, and lugs " L " engaging with the tee-lever " K," the latter pulls down the back stop " C." The gates having been operated, the gate stop lever is then fully reversed and the gate wheel locked.

To restore the gates across the roadway, the gate stop lever is moved to the normal check-lock position, which places the pin " H " on slide " B " in mid-stroke, thus releasing the front stops which, however, are still held down by the projection " M " on the tee-lever " K " The gates are then operated and, when 4/5ths home, the lugs " L " allow the projection " M " to move free of the front stops, and the weights " G " lift them above road level. At the same time the lugs " L " force the lever " K " upwards, which raises the back stop " C "

As the gates approach the back stop, the toes depress the front stops which immediately rise behind the gates and prevent them bouncing back off the back stop. The gate stop lever is then moved fully normal and the pin " H " once more locks the front stops. The final movement of the gate stop lever also locks the gate wheel and releases the levers of the signals for trains to pass over the crossing. It will be noted that separate front stops are provided for each gate. If this were not done the gate reaching the back stop first might be released by the other gate depressing the front stop.

A typical layout of gate connections is shown in diagram 28



GATE CONNECTIONS

DIAGRAM 28

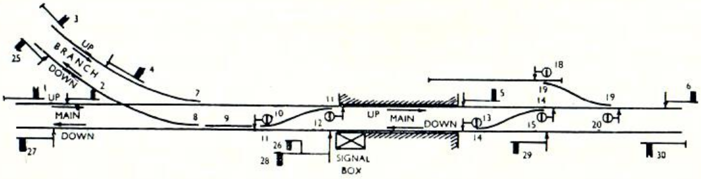
For further details of level crossing equipment reference should be made to booklet No. 25 in this series.

PART V

LEAD-OFF CONNECTIONS FROM SIGNAL BOXES

In leading off rod and wire connections from the signal box, care must be taken in arranging cranks and wheels so that they do not foul one another ; and sets in rods, if unavoidable, should not exceed 3-in. in any direction.

Rod runs should be arranged with the rod to the nearest pair of points nearest to the track, so as to avoid cross rods having to pass under the run, which would tend to make the adjusting cranks thereto inaccessible. Diagram 30 shows a suitable lead-off layout for the signalling arrangements shown in diagram 29. It will be seen that No. 11 points are nearest to the signal box and therefore No. 11 rod is run nearest to the track. No. 9 lockbar connections are next in the group and the junction points Nos. 8 and 7 are the last, in that order.



SPARE LEVERS 16-17-21-22-23-24

DIAGRAM OF SIGNALS

DIAGRAM 29

Lever centres in locking frames vary, the minimum being 4-in. The latter being the more difficult for lead-off, the layout in diagram 30 is drawn for a 4-in. locking frame.

Difficulty is found when three or more consecutive levers operate point rodding, because the crank bases are so close together that they foul the arms of the adjacent cranks. To obviate this "accommodating" cranks are used which have a curved arm to fit around the adjacent crank base, the latter being made 3-in. higher than normal, so that its crank may move over the crank arms on either side of it.

In diagram 30 the lead-off for No. 7 points is fitted with an accommodating crank and the adjacent lead-off for No. 8 points is fitted with a crank on a high base. No. 9 lockbar lead-off crank is of normal type and is clear of No. 8. High crank bases are avoided as far as possible, and it will be noted that by reversing the motion to No. 11 points, an ordinary crank can be used without fouling No. 9 crank. By putting a 3-in. set in No. 14 rod, the crank can be arranged clear of No. 11 without employing a high base.

In leading out signal wires, 10-in. "flat" wheels are used for signals near the signal box ; but for the more remote signals, owing to the great travel of the wire, 14-in. wheels are easier working. When crossing point rods, wires on single wheels pass under the rodding, but in double flat wheels the upper wire passes over the rods. Where a double flat wheel is used, the wheels obviously cannot be in line with *both* lever tails, and the vertical wheel beneath the lever tail is skewed slightly to suit the flat

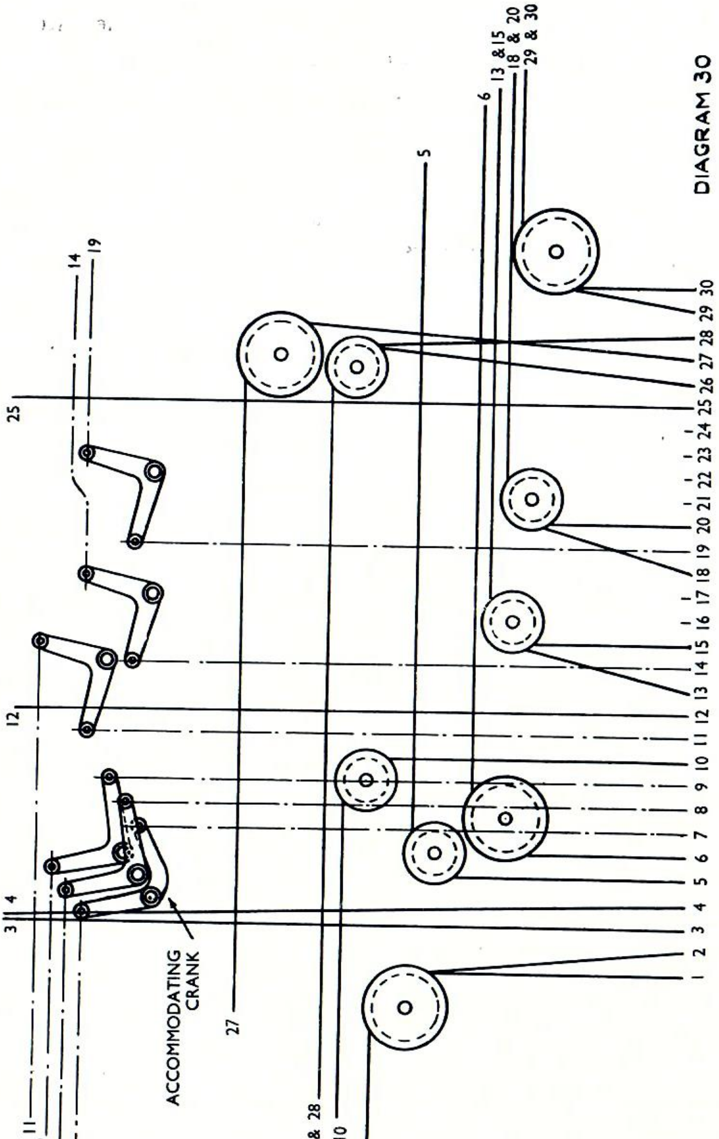

ACCOMMODATING CRANK
1 & 2
26 & 28
13 & 15
18 & 20
29 & 30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

DIAGRAM 30

wheel out of line. If this were not done, the chain would tend to come off the vertical wheel and become wedged in its frame.

In the layout, diagram 29, it is assumed that the wires for signals Nos. 3, 4, 12, and 25 pass straight out across the line and thence alongside the up branch line. All other wires are run alongside the down main, so that six wires run to the left and eight to the right.

The point rodding also would be run alongside the down main ; this arrangement giving the most direct route with the minimum number of cranks.

Space for the lead-off in front of signal boxes is often limited ; and it is frequently found more convenient to take the rod connections *only* out in front, the signal wires passing through openings in the end walls of the signal box or vice versa.